CLAIMS

I claim:

1. An apparatus for reducing laser speckle comprising:

a. a polarizing beam splitter configured to divide a first polarized laser output into a second polarized laser output and a third polarized laser output, the first polarized laser output having a coherence length;

b. a light guide configured to create an optical path difference between the second polarized laser output and the third polarized laser output, the optical path difference being at least about the coherence length, the light guide being configured to direct the second polarized laser output to the polarizing beam splitter such that the polarizing beam splitter combines the second polarized laser output and the third polarized laser output into a fourth laser output; and

c. a depolarizing screen coupled to the fourth laser output, the fourth laser output illuminating the depolarizing screen.

2. The apparatus of claim 1 wherein the light guide comprises a plurality of mirrors.

3. The apparatus of claim 2 further comprising a half wave plate coupled to the first polarized laser output, the half wave plate being configured to adjust a first polarization angle for the first polarized laser output such that the second polarized laser output and the third laser output have intensities that are about equal.

4. The apparatus of claim 3 wherein the depolarizing screen comprises a diffuse reflecting surface.

5. The apparatus of claim 4 further comprising a laser for providing the first polarized laser output.

6. The apparatus of claim 3 wherein the depolarizing screen comprises a diffuse transmitting surface.

7. The apparatus of claim 6 further comprising a laser for providing the first polarized laser output.

8. The apparatus of claim 2 further comprising a laser for providing the first polarized laser output, the laser being configured such that intensities of the second polarized laser output and the third polarized laser output are about equal.

9. The apparatus of claim 8 wherein the depolarizing screen comprises a diffuse reflecting surface.

10. The apparatus of claim 8 wherein the depolarizing screen comprises a diffuse transmitting surface.

11. The apparatus of claim 1 wherein the light guide comprises a polarization preserving fiber optic.

12. The apparatus of claim 1 wherein the polarizing beam splitter divides the first polarized laser output by reflecting the second polarized laser output and transmitting the third polarized laser output.

13. The apparatus of claim 12 wherein the polarizing beam splitter combines the second polarized laser output and the third polarized laser output by reflecting the second polarized laser output.

14. The apparatus of claim 1 wherein the polarizing beam splitter divides the first polarized laser output by transmitting the second polarized laser output and reflecting the third polarized laser output.

15. The apparatus of claim 14 wherein the polarizing beam splitter combines the second polarized laser output and the third polarized laser output by transmitting the second polarized laser output.

16. A method of reducing laser speckle comprising the steps of:

a. dividing a first polarized laser output into a second polarized laser output and a third polarized laser output, the first polarized laser output having a coherence length, the second polarized laser output and the third polarized laser output having orthogonal polarizations and having intensities that are about equal;

b. creating an optical path difference between the second polarized laser output and the third polarized laser output, the optical path difference being at least about the coherence length;

c. combining the second polarized laser output and the third polarized laser output into a fourth laser output; and

d. illuminating a depolarizing screen with the fourth laser output.

17. The method of claim 16 wherein the depolarizing screen comprises a diffuse reflecting surface.

18. The method of claim 16 wherein the depolarizing screen comprises a diffuse transmitting surface.

19. An apparatus for reducing laser speckle comprising:

a. a polarizing beam splitter configured to divide a first polarized laser output into a second polarized laser output and a third polarized laser output;

b. a plurality of mirrors configured to create an optical path difference between the second polarized laser output and the third polarized laser output, the plurality of mirrors configured to direct the second polarized laser output to the polarizing beam splitter such that the polarizing beam splitter combines the second polarized laser output and the third polarized laser output into a fourth laser output;

c. a piezoelectric transducer coupled to at least one of the mirrors, the piezoelectric transducer being driven by an electrical signal such that the optical path difference is varied by an amplitude, the amplitude being at least about a half wavelength of the first polarized laser output, the electrical signal having an electrical signal frequency; and

d. a depolarizing screen coupled to the fourth laser output, the fourth laser output illuminating the depolarizing screen, the electrical signal frequency being at least a sufficient frequency such that laser speckle is reduced.

20. The apparatus of claim 19 further comprising a half wave plate coupled to the first polarized laser output, the half wave plate being configured to adjust a first polarization angle for the first polarized laser output such that the second polarized laser output and the third laser output have intensities that are about equal.

21. The apparatus of claim 20 wherein the depolarizing screen comprises a diffuse reflecting surface.

22. The apparatus of claim 21 further comprising a laser for providing the first polarized laser output.

23. The apparatus of claim 20 wherein the depolarizing screen comprises a diffuse transmitting surface.

24. The apparatus of claim 23 further comprising a laser for providing the first polarized laser output.

25. The apparatus of claim 19 further comprising a laser for providing the first polarized laser output, the laser being configured such that intensities of the second polarized laser output and the third polarized laser output are about equal.

26. The apparatus of claim 25 wherein the depolarizing screen comprises a diffuse reflecting surface.

27. The apparatus of claim 25 wherein the depolarizing screen comprises a diffuse transmitting surface.

28. The apparatus of claim 19 wherein the polarizing beam splitter divides the first polarized laser output by reflecting the second polarized laser output and transmitting the third polarized laser output.

29. The apparatus of claim 28 wherein the polarizing beam splitter combines the second polarized laser output and the third polarized laser output by reflecting the second polarized laser output.

30. The apparatus of claim 19 wherein the polarizing beam splitter divides the first polarized laser output by transmitting the second polarized laser output and reflecting the third polarized laser output.

31. The apparatus of claim 30 wherein the polarizing beam splitter combines the second polarized laser output and the third polarized laser output by transmitting the second polarized laser output.

32. The apparatus of claim 19 wherein the electrical signal comprises a non-square wave signal.

33. The apparatus of claim 19 wherein the electrical signal comprises a square wave signal and further wherein the amplitude is about an odd multiple of the half wavelength of the first polarized laser output.

34. An apparatus for reducing laser speckle:

a. means for dividing a first polarized laser output into a second polarized laser output and a third polarized laser output, the first polarized laser output having a coherence length, the second polarized

laser output and the third polarized laser output having orthogonal polarizations and having intensities that are about equal;

b. means for oscillating an optical path length of the second polarized laser output by an amplitude and with an oscillation frequency, the amplitude being at least about a half wavelength of the first polarized laser output;

c. means for combining the second polarized laser output and the third polarized laser output into a fourth laser output; and

d. a depolarizing screen coupled to the fourth laser output, the fourth laser output illuminating the depolarizing screen, the oscillation frequency being at least a sufficient frequency such that laser speckle is reduced.

18 ~~35.~~ The apparatus of claim ~~34~~ 17 wherein the means for dividing comprises a polarizing beam splitter.

19 ~~36.~~ The apparatus of claim ~~35~~ 18 wherein the means for combining comprises the polarizing beam splitter.

20 ~~37.~~ The apparatus of claim ~~36~~ 19 wherein the means for combining further comprises:

a. a first mirror coupled to the second polarized laser output, the first mirror reflecting the second polarized laser output back to the polarizing beam splitter;

b. a first quarter wave plate coupled to the second polarized laser output between the polarizing beam splitter and the first mirror such that a first polarization angle for the second polarized laser output is

rotated by ninety degrees upon the second polarized laser output returning to the polarizing beam splitter;

c. a second mirror coupled to the third polarized laser output, the second mirror reflecting the third polarized laser output back to the polarizing beam splitter; and

d. a second quarter wave plate coupled to the third polarized laser output between the polarizing beam splitter and the second mirror such that a second polarization angle for the third polarized laser output is rotated by ninety degrees upon the third polarized laser output returning to the polarizing beam splitter.

~~38.~~ The apparatus of claim ~~37~~ wherein the means for oscillating comprises a piezoelectric transducer coupled to the first mirror.

~~39.~~ The apparatus of claim ~~36~~ wherein the means for combining further comprises a plurality of mirrors arranged such that the second polarized laser output returns to the polarizing beam splitter and further such that the second polarized laser output combines with the third polarized laser output to form the fourth laser output.

~~40.~~ The apparatus of claim ~~39~~ wherein the means for oscillating comprises a piezoelectric transducer coupled to one of the mirrors.

~~41.~~ A method of reducing laser speckle comprising the steps of:

a. dividing a first polarized laser output into a second polarized laser output and a third polarized laser output, the second polarized laser output and the third polarized laser output having orthogonal polarizations and having intensities that are about equal;

b. oscillating an optical path length for the second polarized laser output by an amplitude and with an oscillation frequency, the amplitude being at least about a half wavelength of the first polarized laser output;

c. combining the second polarized laser output and the third polarized laser output into a fourth laser output; and

d. illuminating a depolarizing screen with the fourth laser output, the oscillation frequency being at least a sufficient frequency such that laser speckle is reduced.

42. The method of claim 41 wherein the depolarizing screen comprises a diffuse reflecting surface.

43. The method of claim 41 wherein the depolarizing screen comprises a diffuse transmitting surface.

44. An apparatus for reducing laser speckle comprising:

a. means for dividing a first polarized laser output into a second polarized laser output and a third polarized laser output, the second polarized laser output and the third polarized laser output having orthogonal polarizations and having intensities that are about equal;

b. means for switching between first and second optical path lengths for the second polarized laser output, a difference between the first and second optical path lengths being about an odd multiple of a half wavelength of the first polarized laser output;

c. means for combining the second polarized laser output and the third polarized laser output into a fourth laser output;

d. means for diverging the fourth laser output in a first direction to create a fifth laser output;

e. a scanning mirror coupled to the fifth laser output, the scanning mirror reflecting the fifth laser output to create a line illumination; and

f. a depolarizing screen illuminated by the line illumination, the scanning mirror repeatedly scanning the line illumination across a portion of the depolarizing screen such that the means for switching maintains the first optical path length for a first scan, switches to the second optical path length for a second scan, and alternates between the first and second optical path lengths for subsequent scans.

45. The apparatus of claim 44 wherein the depolarizing screen comprises a diffuse reflecting surface.

46. The apparatus of claim 44 wherein the depolarizing screen comprises a diffuse transmitting surface.

47. A method of reducing laser speckle comprising the steps of:

a. dividing a first polarized laser output into a second polarized laser output and a third polarized laser output, the second polarized laser output and the third polarized laser output having orthogonal polarizations and having intensities that are about equal;

b. switching between first and second optical path lengths for the second polarized laser output, a difference between the first and second optical path lengths being about an odd multiple of a half wavelength of the first polarized laser output;

c. combining the second polarized laser output and the third polarized laser output into a fourth laser output;

d. diverging the fourth laser output in a first direction; and

e. scanning the fourth laser output in a second direction across a portion of a depolarizing screen in a first scan with the first optical path length, in a second scan with the second optical path length, and in subsequent scans alternating between the first and second optical path lengths, the second direction being orthogonal to the first direction.

48. The method of claim 47 wherein the depolarizing screen comprises a diffuse reflecting surface.

49. The method of claim 47 wherein the depolarizing screen comprises a diffuse transmitting surface.

50. An apparatus for reducing laser speckle comprising:

a. means for combining a first polarized laser output and a second polarized laser output, the first polarized laser output being incoherent with the second polarized laser output, the first polarized laser output and the second polarized laser output having orthogonal polarizations, whereby a third laser output is formed; and

b. a depolarizing screen coupled to the third laser output.

51. The apparatus of claim 50 wherein the depolarizing screen comprises a diffuse reflecting surface.

52. The apparatus of claim 50 wherein the depolarizing screen comprises a diffuse transmitting surface.

53. The apparatus of claim 50 wherein the means for combining comprises a polarizing beam splitter.

54. The apparatus of claim 50 wherein the means for combining comprises a multilayered dielectric device which transmits the first polarized laser output and reflects the second polarized laser output.

55. The apparatus of claim 50 wherein the means for combining comprises a birefringent crystal.

56. A method for reducing laser speckle comprising the steps of:

a. combining a first polarized laser output and a second polarized laser output to form a third laser output, the first polarized laser output being incoherent with the second polarized laser output, the first polarized laser output and the second polarized laser output having orthogonal polarizations; and

b. illuminating a depolarizing screen with the third laser output.

57. The method of claim 56 wherein the depolarizing screen comprises a diffuse reflecting surface.

58. The method of claim 56 wherein the depolarizing screen comprises a diffuse transmitting surface.

42 59. An apparatus for reducing laser speckle comprising:

a. means for rotating a polarization of a laser output, whereby a rotating polarization is formed, the rotating polarization being driven with a rotation frequency; and

b. a depolarizing screen coupled to the laser output, the rotation frequency being sufficient to reduce laser speckle.

43 60. The apparatus of claim 42 wherein the means for rotating comprises an electro-optic polarization rotator.

44 61. The apparatus of claim 42 wherein the means for rotating comprises a half wave plate, the half wave plate being mechanically rotated.

45 62. A method for reducing laser speckle comprising the steps of:

a. rotating a polarization of a laser output, whereby a rotating polarization is formed, the rotating polarization being driven with a rotation frequency; and

b. illuminating a depolarizing screen with the laser output, the rotation frequency being sufficient to reduce laser speckle.

SUB B1 63. An apparatus for reducing laser speckle:

a. means for dividing a first polarized laser output into a second polarized laser output and a third polarized laser output, the first polarized laser output having a coherence length, the second polarized laser output and the third polarized laser output having orthogonal polarizations and having intensities that are about equal;

b. a light guide coupled to the second polarized laser output, the light guide creating an optical path difference between the second polarized laser output and the third polarized laser output, the optical path difference being at least about the coherence length;

c. means for combining the second polarized laser output and the third polarized laser output into a fourth laser output; and

d. a depolarizing screen coupled to the fourth laser output.

64. The apparatus of claim 63 wherein the means for dividing comprises a polarizing beam splitter.

65. The apparatus of claim 64 wherein the means for combining comprises the polarizing beam splitter.

66. The apparatus of claim 65 wherein the light guide further comprises:

a. a first mirror coupled to the second polarized laser output, the first mirror reflecting the second polarized laser output back to the polarizing beam splitter;

b. a first quarter wave plate coupled to the second polarized laser output between the polarizing beam splitter and the first mirror such that a polarization angle for the second polarized laser output is rotated by ninety degrees upon a first return of the second polarized laser output to the polarizing beam splitter;

c. a second mirror coupled to the second polarized laser output subsequent to the first return of the second polarized laser output to the polarizing beam splitter, the second mirror reflecting the second polarized laser output back to the polarizing beam splitter; and

d. a second quarter wave plate coupled to the second polarized laser output between the polarizing beam splitter and the second mirror such that the polarization angle for the second polarized laser output is rotated by ninety degrees upon the second polarized laser output returning to the polarizing beam splitter.

67. The apparatus of claim 65 wherein the light guide comprises a plurality of mirrors.

68. The apparatus of claim 65 wherein the light guide comprises a polarization preserving fiber optic.